

# Quantum Superluminal Communications

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## Abstract

Based upon quantum entanglement, a simple algorithm for instantaneous transmission of messages (chosen at random) to remote distances is proposed. A special class of situations when such transmissions are useful, is outlined.

Quantum nonlocality arising from entangled states is the most fundamental and the most mysterious phenomenon in quantum mechanics, and it is in the core of quantum information theory. Formally quantum nonlocality follows from the Schrödinger equation; however, its physical meaning is still unclear despite successful experimental confirmation,<sup>[1]</sup> and applications to teleportation, cryptography and computing<sup>[2]</sup>.

The most attractive aspect of quantum nonlocality is associated with instantaneous transmissions of messages. However, practical applications of this effect are restricted by the postulate adopted by many authors<sup>[3]</sup> that these messages cannot deliver any information. That is why all the quantum teleportation algorithms must include an additional (classical) channel.<sup>[2]</sup>

Returning to this postulate, we would like to emphasize that it is implied that the messages cannot deliver any Shannon information. But maybe there are some other measures whose delivery is possible and useful? In this connection, it should be recalled that Shannon information is associated with the degree of unpredictability of the underlying event, and in the physical world that means equal probability for each outcome. However, the situation becomes more sophisticated in biological or social worlds when the underlying system may try to hide its identity by intentionally misleading an observer.<sup>[4]</sup> Then such a property as secrecy or deception, which are the

attributes of the social rather than the physical world, can represent an additional measure of usefulness of the transmitted message. In terms of unpredictability, deception can be associated with disinformation, which makes prediction even harder than in case of maximum Shannon entropy.

In order to illustrate our point, suppose that a sender possesses  $N$  different messages, which he can choose only at random with equal probability, and assume that any of these messages allows each receiver to achieve his goal as long as the secrecy of the message is preserved. (For instance, if a military attack can be conducted in many different ways, the most important is the secrecy of the selected strategy). Then from the viewpoint of Shannon information, the transmission of such a message is useless. However, if one is asked what is the chance that the message can be decoded by a wild guess, the answer will be:  $1/N$ . This means that the number of equally acceptable (but randomly chosen) messages are proportional to the degree of secrecy of the transmission, and that represents the value of this transmission. Actually the sender coordinates and synchronizes the actions of the receivers (regardless of the origin of the message itself) and preserves the secrecy of the communications by making the choice of his message random. It should be emphasized again that the whole procedure makes sense only under the condition that a receiver can use any of these messages to achieve the same objective, but nobody else must know what message has been received.

The communication paradigm described above can be implemented by a simple quantum algorithm. Let us assume that Alice (the sender) and Bob (the receiver) each possess a set of  $n$  particles which are in a one-to-one correspondence such that each pair is entangled; and suppose that they perform a sequence of measurements: one particle per unit time-step. Each measurement performed by Alice has two equally probable outcomes. In case of electrons, these outcomes can be spin-up (+) or spin-down (-). If (+) and (-) are associated with the movements of a point along an axis to the right or to the left, respectively, the sequence of Alice's measurements can be interpreted as a symmetric random walk. Hence, by performing these measurements, Alice selected (randomly) one trajectory out of  $2^n$  equally probable trajectories of the corresponding

random talk. Due to entanglement, Bob instantaneously receives this trajectory (after performing the same type of measurements). Actually Bob's trajectory may look different, but it will be uniquely correlated with Alice's trajectory.

Thus, what has been transmitted? Even prior to the measurements, both Alice and Bob knew that there are  $2^n$  possible trajectories; moreover, they knew how each trajectory could appear. But what they did not know is which one of the  $2^n$  trajectories will be selected; in other words, they did not know the number of the transmitted trajectory if all the trajectories were numbered as  $1, 2, 3, \dots, 2^n$ . However, does this number represent new information? Obviously not since this number has been chosen randomly. Hence, so far, no Shannon or any other measures of information has been transmitted.

Let us consider a special situation when Bob has a certain objective which can be achieved by any of the commands (trajectories) equally well, but under the condition that nobody else will know about the selected trajectory. Now we are moving to the world where such measures as degree of secrecy or deception may be more important than Shannon information. Indeed, the fact that the command has been chosen randomly becomes useful: it hides this command among  $(2^n - 1)$  others. At the same time, the fact that the transmitted Shannon information is zero becomes irrelevant since each command is equally effective anyway.

So what has been transmitted now? The answer is: the degree of deception. Indeed, the probability that the selected trajectory can be decoded by a wild guess is  $2^{-n}$ , i.e., vanishingly small for  $n \gg 1$ .

It should be noticed that the command is transmitted instantaneously regardless of the distance between Alice and Bob, and the number of receivers like Bob can be arbitrarily large as long as each receiver has a set of  $n$  particles entangled pairwise with the corresponding particles of the sender. At the same time, the secrecy of the command is preserved by the fact that the knowledge about the selected trajectory is acquired at the

moment of measurement, and therefore, only the sender and the receivers possess the secret command.

Thus, a simple quantum algorithm for instantaneous transmission of randomly chosen messages on remote distances is proposed. The novelty of the algorithm is in re-interpretation of the measure of usefulness of a message. Based upon the Shannon information, transmission of randomly chosen commands are useless. However, we have introduced a special class of situations when such transmission makes sense. These situations must satisfy the following conditions: each of the randomly chosen commands is equally useful for the receiver to achieve his objective, and the transmitted command must be kept in secret until its execution. Both of these conditions are usually satisfied in the military world when the deception effect of the chosen strategy is more important than the strategy itself.

One should notice that the new measure of the usefulness of a message is based on the attributes of the social world such as deception, secrecy, decoding, in contradistinction to the Shannon information, which is based upon the attributes of the physical world (such as entropy). It should be made clear, however, that the proposed algorithm does not violate the postulate about the impossibility to transmit the (Shannon) information.

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